shall be led to utilize, cost what it may, the first carriages that are offered. Perhaps it would be better to occupy ourselves with this matter in advance. In order to obtain a serious result, we must, I repeat, make application to real owners of carriages, who possess automobiles put in perfect trim and arranged with a view to campaign purposes.

Now, upon examining things closely we shall perceive that owners who are still of the age to do military duty are not as numerous as might be thought; so, the best thing to do would be to make sure of their aid at once.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of G. de Pawlowski in La France Automobile.

[Continued from SUPPLEMENT No. 1580, page 25314.]

RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—II.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

RESERVOIR PENS.

MANY attempts have been made to increase the ink-holding capacity of the ordinary writing pen, or nib. As already mentioned, one method of attaining this end, was the provision of an orifice or "pierce" as it is technically called, some examples of which are shown in Fig. 12.

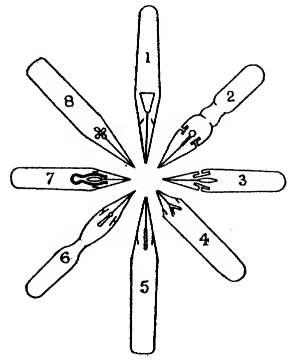
Some nibs were provided with deep recesses or pockets as shown in Fig. 13 (*A*); Fig. 14 (*B*); Fig. 15 (429, 1883). Another favorite method was that of folding over the sides of the nibs. The nib was stamped out provided with wings, which could be folded, so as to form an ink reservoir under the nib, as in Fig. 16 (*C*); Fig. 17 (1616, 1890), and Fig. 18 (10984, 1884).

Sometimes a portion of the nib was so punched out serted in a tubular holder containing a supply of ink which would gravitate to the point.

Illustration Fig. 43 (8748, 1892) shows a barrel pen formed from a flat piece of steel, bent into a tube, tapering toward the point. And the adjoining illustrations Fig. 44 (13665, 1888), show a somewhat similar pen, having four points meeting to form the writing point. The illustration, Fig. 45 (18020, 1899), shows a trough formed underneath the nib.

Several inventors have used India rubber in com-

FIG. 12.



marily intended for a reservoir nib. The nib proper has no slit, but the combination of its point with the point of the overhanging plate (which, it will be observed, projects slightly beyond the nib point) forms an elastic writing point, the ink being delivered from between the two points, the object being to produce a pen having the sensation of a quill in writing.

The foregoing examples are merely typical and do not by any means exhaust the number of attempts to produce a reservoir nib. Some of them are very well in their way, and some are ingenious. They obviate the necessity of frequent dippings in the inkpot, for with some of them it is claimed that a letter may be written with one dip of ink.

So far so good, but something more is demanded. A lead pencil may be carried in the pocket, ready for use at any moment, where such an instrument is permissible. The aniline pencil came to meet a want, by supplying a more or less indelible marking agent. Ink, however, was not to be ousted, as, with its drawbacks, it is to-day the most suitable article for writing, a good ink being as permanent (and often more so) as the material upon which it is used. There was room, therefore, for some kind of pen which would carry a supply of ink sufficient to last a considerable time, and yet such a pen as could be carried in the pocket without risk of its being emptied where least wanted.

(To be continued.)

BENARES.

HINDUISM reveals at Benares perhaps more clearly than anywhere else one of the secrets of its hold over so many millions of people. It is both eclectic and popular. For the Hindu pilgrim not only finds here such a pantheon of the innumerable deities which are,

FIG. 13.

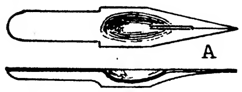


FIG. 14.

FIG. 15.

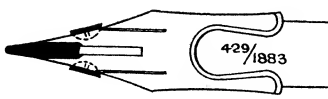


FIG. 16.

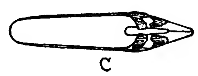


FIG. 17.

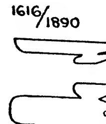


FIG. 18.

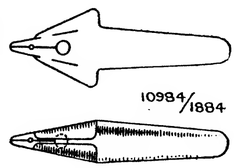


FIG. 19.

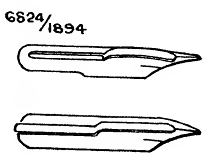


FIG. 20.

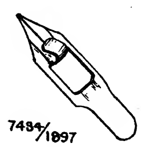


FIG. 21.

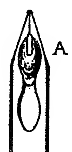


FIG. 22.

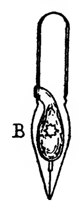


FIG. 23.

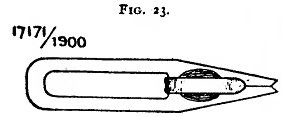


FIG. 24.

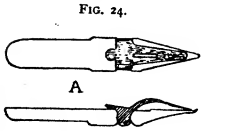


FIG. 25.

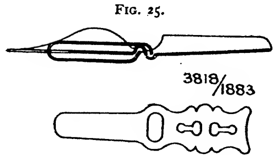


FIG. 26.

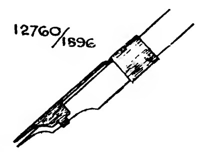


FIG. 27.

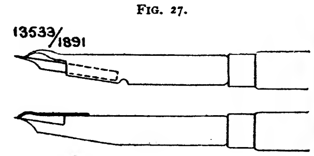


FIG. 28.

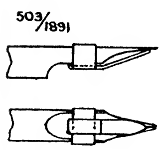


FIG. 29.

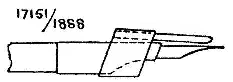


FIG. 30.

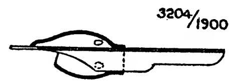


FIG. 31.

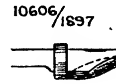
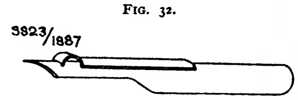


FIG. 32.



that it could be folded over on the back of the nib, as in Fig. 19 (6824, 1894), and Fig. 20 (7484, 1897). Or underneath the nib, as in illustrations Fig. 21 (*A*), and Fig. 22 (*B*), the space thus formed providing accommodation for a considerable quantity of ink. In some instances the folded part was used as a clip as in Fig. 23, to hold a pellet of aniline matter, so that on dipping the nib in water, a writing fluid resulted. Messrs. Perry & Co., some fifty years ago, introduced a similar nib, having an aniline pellet cemented underneath, and these nibs were sold at what now appear to be very extravagant prices.

Not uncommonly nibs were provided with additional parts, which were either fixed by clips or other means, as shown by Fig. 24 (*A*), Fig. 25 (3818, 1883), Fig. 26 (12760, 1896), and Fig. 27 (13533, 1891), and also in Fig. 28 (503, 1891), Fig. 29 (17151, 1888), Fig. 30 (3204, 1900), Fig. 31 (10606, 1897), and Fig. 32 (3823, 1887), or were slipped into the penholder together with the nib, as shown in Fig. 33 (16516, 1888), Fig. 34 (12999, 1896), Fig. 35 (20862, 1895), Fig. 36 (21138, 1891), Fig. 37 (*A*), and Fig. 38 (15309, 1886), or were part of the penholder, as in Fig. 39 (*B*). Another form was that in which the sides of the nib were bent into trough form, and a wire having a coiled loop was attached to the nib, lying along the bottom of the trough as in Fig. 40 (16235, 1891), or a fine wire was wound around the point of the nib, as shown in Fig. 41 (2328, 1889).

In the illustration Fig. 42 (155, 1883) we have a kind of barrel pen having a reservoir formed underneath the writing point, while the "barrel" may be in-

* Journal of the Society of Arts.

bination with nibs as a means of holding ink. In the first example, Fig. 46 (3808, 1893), a tiny piece of thin sheet rubber is punched out, as shown at *A*, and this is fitted to the nib by inserting the point into the openings provided. The next example, Fig. 47, is very similar (18482, 1895). In the next illustration, Fig. 48 (3788, 1894), a short piece of India rubber tubing is used; and in the fourth example, Fig. 49 (12963, 1895), a nib, of barrel form, is almost entirely inclosed in a flexible rubber tube, the point of the nib being visible.

The remaining example, Fig. 50 (7241, 1897) shows a piece of flat rubber, the ends of which are held taut by a metal ring clasping them to the penholder, while the point of the nib is just visible through a minute hole in the rubber.

In drawing Fig. 51 (12618, 1895) is shown a nib with an exaggerated "pierce" extending in tapering form about one-half the length of the nib. Into this perforation is sprung a piece of flat metal, bent like a pair of forceps. It is possible that a considerable quantity of ink might be held here, but the pen is too clumsy to meet with universal approval.

The illustration, Fig. 52 (2561, 1870), shows an addition to a nib, having a kind of counterpart pivoted underneath, and held in position against the nib by a tall spring. Although patented in 1870, this has recently been offered as a novelty.

A more recent patent, Fig. 53 (10583, 1891), is also illustrated here, in which two nibs are held together in a holder, face to face, the cavity forming an ink reservoir; and another drawing shows the lower nib pivoted into the upper one, suggestive of a bird's beak.

In Fig. 54 (3211, 1872) we have a nib which it is convenient to refer to here, although it was not pri-

according to the higher Brahminical teaching, merely the symbolical manifestations of the one Supreme Being, that, whatever part of India he comes from, he will discover some shrine sacred to his own favorite cult, but he can also within this small area visit sacred spots assimilated in point of sanctity to different holy places in remote parts of India and acquire the spiritual benefits of other famous pilgrimages without the toil and expense of further journeyings. Thus the Hindu from the northern plains of India can obtain at a given shrine in Benares, all the merit of a pilgrimage to Ramosvaram without traveling to Cape Comorin; and the dweller in the south, who has found his way to Benares, need not toil up into the Himalayas to earn the reward of a pilgrimage to Kedarnath. But comprehensive as is the hospitality of Benares to the vast company of gods and goddesses, it does honor, above all, to Shiva Mahadeva, or the great god whose cult is certainly the most popular and widespread at the present day—Shiva, the Lord of Life and Death, the Destroyer and the Creator, whose *sakti* is the terrible goddess, Durga, or Kali, whom blood alone can propitiate. Vishnu has left his footprints at Benares, and there are temples to Ganesha, the elephant-headed, and Hanuman, the monkey-faced, and to scores of other major and minor deities, but it is to Shiva in one or other of his manifestations that not only the great Golden Temple, but by far the largest number out of the 1,400 temples and innumerable lesser shrines of Benares are dedicated, and it is to obtain from him as Lord of Bliss, immediate admission into his reposeful realm, that the funeral pyre is kindled on the "burning *ghat*" and the ashes of the dead committed to the waters of the Sacred River.

The whole life of Benares revolves on the axis of sacrificial virtue. At the first break of dawn the daily host of pilgrims descend to the river's edge, and in sight of the rising sun perform their ablutions with an elaborateness of ritual which reaches its utmost development in the case of the twice-born Brahmin. So great is the spiritual potency of Ganges water that for the moment even caste is obliterated and the low-caste Sudra can bathe alongside the high-caste Brahmin without polluting him. Then during the forenoon a stage has to be done of the long pilgrimage through the narrow streets of the crowded city to the sacred wells and to the temples and shrines which crowd upon each other in its labyrinthine alleys like the growth of a tropical forest; and when this "perambulation" of the Holy City has at last been completed with endless offerings of flowers and rice to the gods, and libations of sacred water on the divine emblem of Shiva, and sacrifices of goat's blood to the "terrible goddess," and now and again a passing tribute of sugar-cane or green fodder to the sacred cows, no less insistent than the army of human mendicants, the indefatigable pilgrim proceeds to the great "circumambulation" of the outer limits of the Holy City, which occupies six more days. From year's end to year's end the tide of pilgrims flows perpetually, reaching the flood at certain festival seasons, but never altogether failing. And in return the whole life of Benares is dedicated to the pilgrims' service—for value received. To provide for his spiritual needs there are Brahmins to guide him on his pious errands and to recite on his behalf the most potent *mantras*, there are Sanyiasis and Saddhus to display for his benefit the most approved methods of penitential asceticism, there are qualified priests to certify that he has duly observed every iota of the pilgrim's ritual. For his material wants there are numberless hostelries and eating houses, where he can obtain food and shelter in accordance with the rigid requirements of his particular caste, there are whole streets where nothing is sold but the brass pots for ablutions, and the flowers and rice for sacrificial offerings, or the small idols and images in brass which he carries home with him as the mementoes of his pilgrimage. Even the palaces of massive stone and marble which rise in almost unbroken array along the great river *ghats* are little else than royal hostelries for pilgrims, erected by the splendid piety of Hindu princes from all parts of India for the use of their families and retainers.

Many have been the pictures painted with pen and brush of the wondrous life of Benares, so full of color and sunshine, so fascinating in its splendor, so repellent in its squalor, so mysterious in its remoteness from every western conception, and, above all, so ancient and unchanging. At Benares, perhaps as nowhere else, one realizes the meaning of the immutable East. Some four thousand years have passed since the great Aryan migration from northern climes into the plains of India which brought forth in due time by unknown processes of evolution the social and religious system which we call Hinduism. Traditions of peculiar sanctity may have attached to the country about Benares even before the advent of the northern Aryans. That it was singled out by them at a very early date as a holy place there can be no manner of doubt, for, thanks to a sudden northerly sweep of the Ganges, the bend of the Sacred River on which Benares has been built faces auspiciously toward the rising sun and Shiva's Abode of Bliss. Since then throughout the procession of the ages kingdoms have risen and fallen, conquerors have come and gone, great religious teachers have appeared and disappeared, but the ancient cult of which Benares is the supreme sanctuary has survived them all, unchanged and unchanging. More than 24 centuries ago Buddha preached hard by Benares, and the ruins of Sarnath still bear witness to the shortlived glory of Indian Buddhism. Less than three centuries ago Aurangzeb tore down a temple of Shiva in the heart of Benares and built a mosque on its site with four lofty minarets as a standing testimony to the supremacy of Islam. To-day the Dufferin railway bridge which spans the Ganges just below Benares city is an eloquent monument to the material triumphs of another alien race and another alien civilization on the ancient soil of India. Will the influences for which that great bridge stands affect any more permanently or deeply the unchanging course of Hindu life?

Perhaps the most pertinent answer to that question might be found in the records of the Indian National Congress, which, with that strange absence of humor characteristic of the Bengali mind, has chosen Benares of all Indian cities as the meeting place of a mimic western parliament. Political rights and political liberties, which have grown up in western countries as the matured fruit of a laborious social evolution, form the burden of their discussions, but seldom the duties correlated to those rights and liberties, and still more rarely the social conditions, as far as the poles asunder, which underlie them. The keynote of western society is individualism—the freedom of the individual to develop according to his natural capacities and the opportunities afforded by an elastic social framework. The keystone of the Hindu social structure is caste, which is the absolute negation of individualism—iron bound, pitiless caste, which immures the individual from his cradle to his grave within the prison house of immutable laws, customs, and traditions. What impression has contact with the West produced upon caste? One often hears it stated that the appliances of western civilization, railways, street cars, factories, etc., with the facilities and even the necessity of contact between different classes of the community, are gradually breaking down caste, and no doubt some of the superficial observances of caste have been relaxed in practice, though not in principle. But the touchstone of caste is the right of intermarriage—the old *jus connubii*—and the rigidity of the caste-laws which govern that vital point remains absolutely unshaken and untouched. That is the rock upon which the more earnest reform movement, such as the Brahmo Somaj and the Aryo Somaj, have come to grief, and which the glib talkers of the national congress seek to avoid by ignoring its existence. But so long as Hinduism rests upon that rock, Benares will remain what it has been for thousands of years and what it still is to-day—the center of a great immovable world of spiritual conceptions and emotions which defies the Western understanding as completely as the Western world of action and material energy passes the Hindu comprehension.—London Times.

Ferro-Manganese.—Ferro-manganese is attacked by water; the higher the percentage of manganese the greater is the energy of the reaction. This fact, say Herren Naske and Westermann, in Stahl u. Eisen, is due to the presence of manganese carbide, which is decomposable by water, while ferric carbide is not. In any case, the sulphur and phosphorus contained in the alloy do not cause the attack of water, which is demonstrated by the absence in the gases collected of hydrogen phosphide or sulphide. The attack of the ferro-manganese by water is slow when cold, more energetic when hot, and the gases are especially composed of hydrogen and carbonic acid. Their quantity is a function of the percentage of manganese, and not of that of carbon.

PRACTICAL METHODS OF WATERPROOFING AND FIREPROOFING.

By DR. KOLLER.

FOR making textile fabrics and pasteboard incombustible, the following methods have stood the test especially well:

1. For Light Woven Fabrics.—Ammonium sulphate 8 parts by weight, ammonium carbonate 2.5 parts, borax 2, boracic acid 3, starch 2, or dextrin 0.4, or gelatin 0.4, water 100. The fabric is to be saturated with the mixture, previously heated to 86 deg. F., and dried; it can then be calendered in the ordinary way. The cost is only two or three cents for sixteen yards or more of material.

2. For Wood, Rope, and Straw Matting.—Ammonium chloride (sal-ammoniac) 15 parts by weight, boracic acid 6 parts, borax 3, water 100. The articles are to be left in the solution, heated to 212 deg. F. for about three hours, then squeezed out and dried. The mixture costs about five cents a quart.

3. For Paper.—Ammonium sulphate 8 parts by weight, boracic acid 3 parts, borax 2, water 100. The temperature should be about 122 deg. F.

Uninflammable Starch.—Sodium tungstate, perfectly neutral, 30 parts, borax 20, wheat or rice starch 60. The constituents are to be finely pulverized, sharply dried, and mixed, and the starch used like any other. Articles stiffened with it, if set on fire, will not burst into flame, but only smolder.

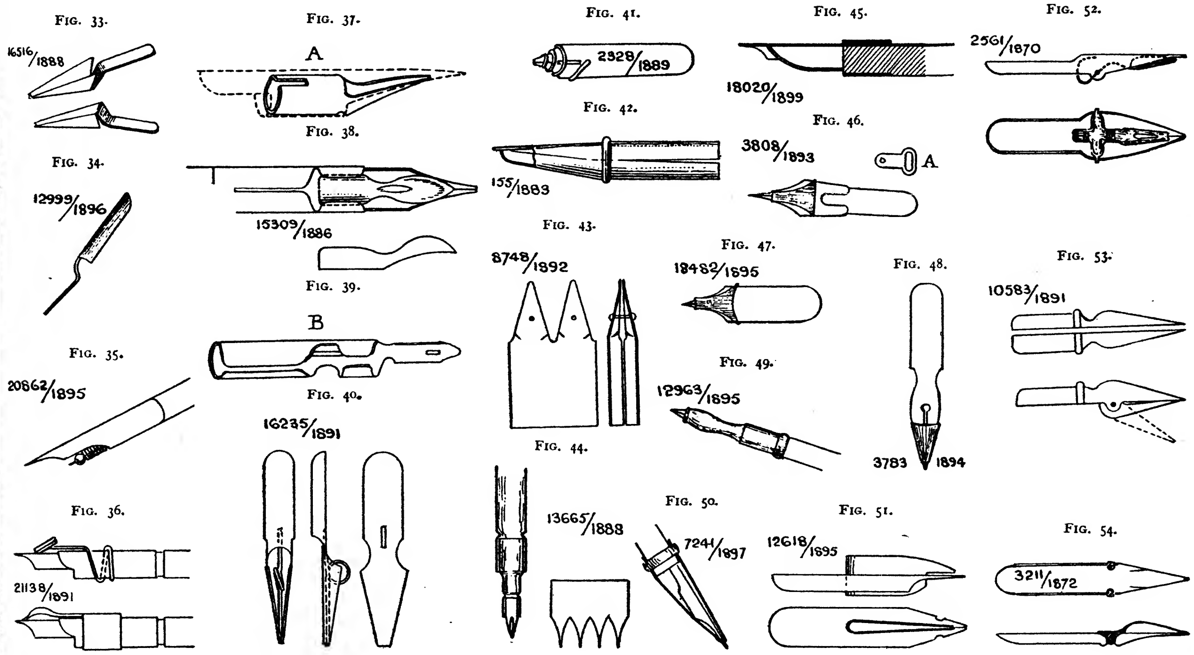
For waterproofing sacking, the two methods given below may be used with advantage:

1. Dissolve separately equal weights of alum and sugar of lead—lead acetate—in hot water, with stirring; put the solutions together and add warm water; let the goods lie in this liquid for twenty-four hours, then remove and dry.

2. Boil 50 parts by weight of isinglass in soft (rain) water until fully dissolved; dissolve 100 parts of alum in 3,000 parts of water, and 30 parts of white soap in 1,500 or 2,000 parts of water; mix the filtrates of these solutions and apply to the cloth, quite hot, with a brush.

To Make Tent Canvas Waterproof.—130 parts by weight of litharge, 130 of umber, and 11,000 of linseed oil. (For a tent of medium size, a sufficient quantity of the liquid will be made by using 4½ ounces of litharge, 4½ of umber, and 3 gallons of oil.) Boil the mixture for 24 hours, stirring frequently, in a vessel large enough so that the mass cannot boil over, on a stove-lid, not over an open fire. Apply while warm to the cloth, stretched on the tent poles, and let it dry in the sun. It is well to do this in the morning, so that the canvas will be fairly dry before the dew falls at night.

For waterproofing woolen or half-woolen materials, make a mixture of 100 parts of gelatin (animal glue), thoroughly dissolved, and 100 parts of potash-alum, and add water as necessary, according to the weight of the material, and the degree of hardness desired in the waterproof finish. After applying the mixture, the material is dressed a second time with a mixture of 5 parts of tannin and 2 of water-glass, and then



[Continued from SUPPLEMENT No. 1586, page 25408.]

RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—VIII.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

FOUNTAIN PENS.

IN Fig. 174 (O. Winkler, 1898, 12805), the hollow ink holding pen handle, *A*, is by preference made of glass, and is tapered and curved at the forward end to supply the nib, *N*, which is held in the sliding barrel, *B*. The rubber air ball, *C*, is fitted with a sliding valve, *V*, to control the admission of air, and thus regulate the flow of ink.

The Eagle Pencil Company has designed (1898, 15766), some forms of feed bars, or ink-feeding plugs, as the inventor calls them, for conveying ink from the reservoir to the nib. One of these consists of a tube slotted along the top to receive a tongue, which separates it into two unequal channels.

Fig. 175 (J. Blair, 1898, 17118) shows in part section a reservoir pen in which powdered ink is used. A dry ink cartridge, *C*, is carried in a porous bag, covered at its forward end by a piece of sponge, *S*. Soft water is poured into the reservoir to dissolve the ink powder. Otherwise this pen does not call for any remark.

The pen patented by J. H. Burton (1899, 595) was provided with two ink reservoirs and two writing points. One design shows a feed bar having an ink inlet communicating by means of spiral ducts with the ink supply at the upper side, so as to be in contact with the under side of the nib. Another arrangement shows a somewhat similar feed bar provided with a inner surface is free to move and depress the surface of the flexible rubber chamber, *F*.

In Fig. 178 (Salisbury, S. M. & E. C., 1900, 10905) the casing, *A*, is made in two separable parts, connected by a sliding joint, *J*. The ink reservoir, *B*, is made of rubber and is attached to the nipple, *N*, and to the steadying button which loosely fits into an opening, *O*, at the back of the casing, *A*. The ink guide, *D*, consists of a bent wire terminating in a flat paddle, *W*. The nib is held in place by the barrel, *E*.

The feed arrangement of another pen (C. J. Holm, 1900, 11049) consists of a plug, provided with a central duct, in which is inserted a short tube leading to a rubber tube, fitted with a glass mouthpiece, which delivers the ink to the nib.

The peculiarity of the pen shown in Fig. 179 (W. F. Cushman, 1900, 11580) is, that when out of use the nib may be withdrawn into the barrel as shown in the drawing. The nib is carried at one end of the spindle, *B*, sliding through the plug, *C*, and is connected by the screw-plug, *G*, with the sleeve, *F*. When the cap, *H*, is removed from the front of the pen, the sleeve, *F*, and the spindle, *B*, are pushed forward, carrying the nib into position for writing. This appears to be Moore's non-leakable pen.

The ink in F. E. Clarke's pen (1900, 12658) is supplied to the nib through a tube, which may be partly or entirely closed by a tapered wire secured to the screw cap.

In Fig. 180 (H. Grass, 1900, 16558), the nib, *N*, is shown held in slits in the block, *K*, and supplied with ink by the sponge or wad contained in the chamber, *J*. Caw pen, and issued by Messrs. Eyre & Spottiswoode.

Having now indicated the most important features of many of the fountain pens which have from time to time been invented, I will briefly describe some of those of more modern date or at present in use.

The "Sackett" pen shown in Fig. 184 has already been described in detail. This drawing, however, shows the tongue in plan, and also a cross section of the grooved feed-bar. No further description is perhaps necessary.

The "Quill" pen, Fig. 185, of Mr. W. S. Hicks, whose name is well known as the maker of pocket pencils, is something like the "Wirt" (described later) as regards its feed-bar. This is, however, about treble the length of that of the Wirt pen, and terminates in a wavy form, as shown, and similar in this respect to the Sackett pen of 1886. The undulations of the feed bar are so designed that they equal the internal diameter of the barrel or ink reservoir, so that in re-filling the pen with ink it is not necessary to withdraw the feed-bar completely, as the elasticity of the latter, acting against the barrel, holds it in a suitable position to permit of re-filling.

On reference to the drawing, Fig. 186 (De la Rue's "Pelican" safety fountain pen), it will be seen that the holder consists of three parts, viz.: The pen carrier, *F*, the body, *C*, and the plug, *H*. The body, *C*, is so constructed that it may be screwed into the pen carrier, *F*, until it closes the two apertures, *A* and *B*. By the reverse process the apertures are opened as shown in the drawing. The lower aperture, *A*, communicates with the duct, *G*, whereby the ink is le[d]

Fig. 174.

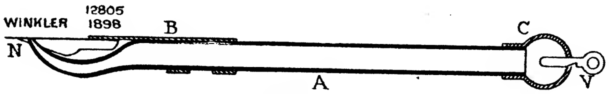


Fig. 175.

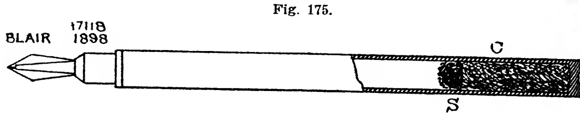


Fig. 176.

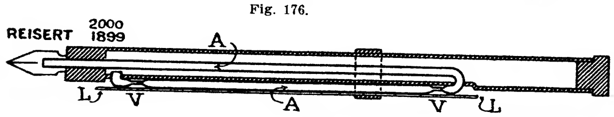


Fig. 177.

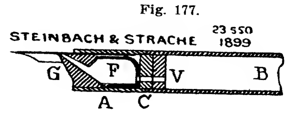


Fig. 178.

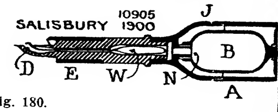


Fig. 179.

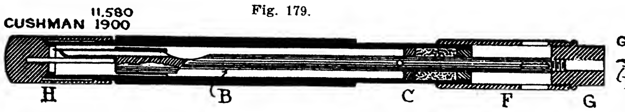


Fig. 180.

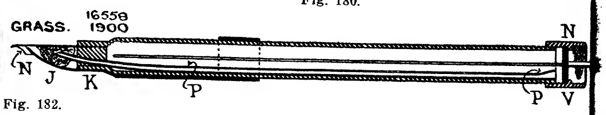


Fig. 181.

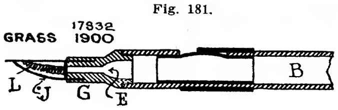


Fig. 182.

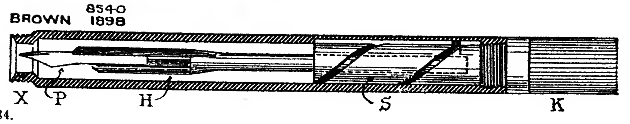


Fig. 183.

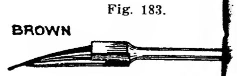


Fig. 184.

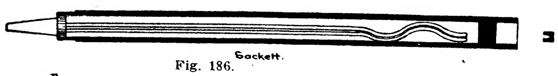


Fig. 185.

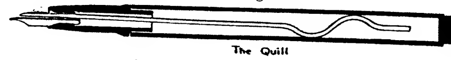


Fig. 186.

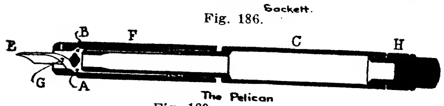


Fig. 187.

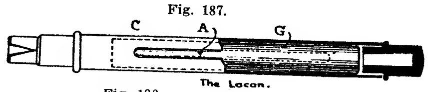


Fig. 188.

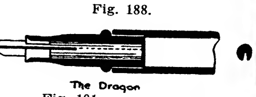


Fig. 189.

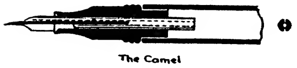


Fig. 190.

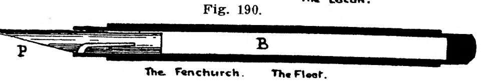
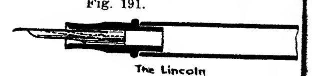


Fig. 191.



screw thread engaging with the point section, and having an elongated ink duct which tapers toward the inner end, so that by screwing the piece in or out, the ink supply may be regulated.

In the drawing, Fig. 176 (E. Reisert, 1899, 2000), it is seen that the reservoir supplies ink to the nib through the flexible syphon tube, *A A*. The supply is controlled by pressing on the lever *L*, at intervals, thus closing and opening the passages at the strictures or valves, *V V*. Ink enters at the bottom of the reservoir and travels up the shorter limb of the syphon, and is delivered to the nib at the extremity of the longer limb.

Another pen (R. Cofani, 1899, 10869) had a flexible rubber reservoir. The nib is carried in the holder, to which is pivoted the pressure piece. Ink is contained in the reservoir, and is forced through the supply tube by the action of the pressure piece when the nib is brought in contact with the paper.

In F. C. Edgar's pen (1899, 21195), the nib is held by the barrel above the elongated opening of the ink duct which is supplied from the reservoir. An outer casing protects the whole.

In Fig. 177 (Steinbach & Strache, 1899, 23550) the reservoir, *B*, and front tubular portion, *A*, are screwed on the plug, *C*. The flexible rubber chamber, *F*, supplies the nib with ink, through the beak, *G*, and communicates with the reservoir, *B*, by means of the eccentrically placed channels in the plug, *C*, and the valve, *V*. The nib is so secured, that when in use, its

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A piston valve, *V*, is provided at the other end with which the rear end of the ink supply tube, *P*, may be closed. Extra wads are kept in the upper end of the cap.

The nib in Fig. 181 (H. Grass, 1900, 17832) is secured in a slit in the plug, *G*. Ink passes from the reservoir, *B*, through the duct, *E*, and is conveyed to the nib by the spiral spring, *L*, inclosed in the chamber, *J*. An opening is provided in the outer metallic case, so that the interior flexible rubber reservoir may be compressed slightly by the finger in writing.

In H. W. Dixon's pen (1900, 23567), the ink is sucked into the reservoir by turning the head, until the lower end of the inner tube is unscrewed from the plug. The inner tube may then be slowly withdrawn, and ink thus sucked upward. When the reservoir is charged sufficiently, further withdrawal of the tube is prevented by wire stops, it is then inverted, and the tube may be moved back into the other extreme position.

In Fig. 182 (F. C. Brown, 1898, 8540), the nib, *P*, is held between the upper and lower tongues of the feed bar, *H*, which terminates in the form of a rod. A sleeve nut, *S*, is attached to the cap, *K*, and may be rotated by it. A pin in the rod, *H*, fits in the groove of the nut, *S*, and as the latter is rotated causes the rod, *H*, to travel in an upward or downward direction, as desired. The nib may thus be drawn within the nozzle, and the cap provided may then be screwed on at *X*, making a non-leakable joint.

Fig. 183 shows the forward end of the triple feed-bar now used in connection with the pen, known as the

along the upper surface of the nib to the point, *E*. The duct, *B*, at the same time admits an equal volume of air to replace the ink as used in process of writing. The plug, *H*, is unscrewed for the purpose of recharging the holder with ink, before doing which the apertures, *A* and *B*, must, of course, be closed as already described. By the courtesy and kindness of Mr. Evelyn De la Rue, I have had the privilege of seeing these pens made, and it gave me much pleasure to notice the accuracy with which the various parts are made and fitted together, and the great care exercised in turning out an implement as perfect as possible.

This pen (the "Lacon" pen, Fig. 187) has already been described, and calls for no further comment.

The feed bar of the "Dragon" pen, shown in Fig. 188) is partly cylindrical with a V-shaped groove extending along its under side. The front end is prolonged in the form of a tongue which rests on the upper surface of the nib. The pen from which this drawing was made was submitted to me by the American Pencil Company. It has a tapering cap which is perhaps an advantage, as it tends to keep a better balance when writing.

The feed bar of the "Camel" pen, of Messrs. Ormiston & Glass, in Fig. 189, consists of a single rod fitting into a point section. It has grooves and passages for ink and air as shown in the drawing. The front end terminates in a single top feed tongue, and a slit extending backward about half way for the reception of the nib.

Fig. 190 (the "Fleet" pen) shows an exceedingly low-priced fountain pen, the specimen in my collection costing the modest sum of 6½d. It consists of a barrel or ink reservoir, B, and a plug, P, which almost fills the neck of the barrel. This plug is circular in section, cut away diagonally at the front end, to a point. A saw-cut groove extends longitudinally along its upper side, nearly to the point, while underneath is a cut or gash, which almost divides the plug into two parts. This latter acts mechanically as a spring, so that when the nib and plug are together placed in the barrel, both are held firmly in position. It is intended that almost any suitable form of metal or steel nib may be used, and not necessarily a gold one.

The "Lincoln" pen shown in Fig. 191 has nothing very special to speak of. It has a simple form of single undertype feed, and the pen takes its name from that of one of the most popular of the United States Presidents. I am informed by Messrs. Deverell, Sharpe & Gibson that Messrs. Perry & Co. claim the name, "Lincoln," as applied to pens of all descriptions, so that the "Lincoln" fountain pen is now known as the "Devarson," a name built up of syllables from the names of the members of the firm. Since writing the foregoing, I have tested the "Devarson" pen, and I can vouch for its excellence. The feed is simple, and effective.

Fig. 192 shows the business end of the "Stafford" pen. Like Fig. 191, and many other pens of very high excellence, it is produced in the United States. Its feed bar is a combination of that of the Waterman pen of 1884, in that it has parallel saw-cut ducts extending along its upper half, and it also resembles the feed bar of Prince's pen of 1855, in that it has a thin vulcanite tongue, a plan of which is shown on the drawing, which lies along the ink duct and vibrates with the action of the nib. The feed is very satisfactory, and I like the pen on account of its capacity for ink. Although I have fitted it with a "Swan" nib, I have found it very reliable.

Fig. 193 shows the point section of the "Swallow" pen, and just enough of the feed arrangement is visible to show that it bears a very striking resemblance to that of the Swan pen of 1895. Imitation is said to be the most sincere form of flattery, and probably the maker of the Swallow pen knows a good thing when he sees it.

In Fig. 194 is shown the point of the "Parker" pen, known as the "lucky curve" pen. A saw cut commences at the rear end of the feed bar, almost dividing it in two parts, and then traverses the upper surface, reaching nearly to the point, where it disappears. Air is admitted through a small hole, entering at the under side, as indicated by the arrow, and passes upward to the saw cut.

The "Swan" pen (Fig. 195) is perhaps a household word. There are those who think, or perhaps they do not think, that the name "Remington" covers all typewriting machines that ever were invented. Some firmly think that all hand cameras are Kodaks, and there are also many who no doubt think that "Swan" is a sort of generic name for fountain pens. Be that as it may, Messrs. Mabie, Todd & Bard have not been wanting in energy and painstaking ability to make the fountain pen popular. Their pens are known, and deservedly so, throughout the civilized world. As a matter of fact I wrote these words with one of their gold nibs purchased thousands of miles away, and used for many years in the Friendly Islands. It now glides smoothly and silently along, although it is adapted to a different holder and feed arrangement to that for which it was originally intended. The feed arrangement of the "Swan" consists of two parts. The feed bar is of the double type, that is to say, the bar is divided for about one-half its entire length into two tongues, between which the gold nib is placed so that there is a tongue on the top of the nib which reaches to within a short distance of its point, and a second tongue lies snugly on the underside of the nib, being about 1/8 or 3/16 of an inch shorter than the upper one. This feed bar being originally tubular is grooved longitudinally along its inner surface forming ducts whereby the ink is led to the nib. Besides the feed bar proper there is a twisted silver wire, the polished surface of which repels the ink, and in doing so provides a means of conducting air to the ink chamber, thereby completing the circulation. Without unduly giving prominence to the "Swan" pens, I would say that I have carried one of them for some time, and I have always found it reliable. It is always ready to write as soon as it touches paper, and it has never yet emptied its contents where not required. Mr. Watts, the London manager of this firm, has rendered me much service in connection with my lectures, in showing me many pens now obsolete, while on the other hand I have had pleasure in showing to him others, of the existence of which he had not previously known.

In Waterman's "Ideal" fountain pen (Fig. 196) the great charm lies in its simplicity. In every fountain pen the feed is the all-important detail that makes or mars its success. The feed of the Ideal is the essence of simplicity. It is strong, and unlikely to get out of order, and it insures a copious supply of ink at the business end of the nib, without fear of delivering it too quickly. The drawing shows one of these pens in section. It will be noted that the feed bar, B, contains a grooved duct or passage, extending almost to its entire length. This duct is about one-sixteenth of an inch wide, and along the bottom of the duct are parallel saw cuts by which the capillary action is secured. Cross sections of the feed bar were shown earlier. A later improvement has been effected. On either side of the duct, pockets or recesses are formed, which were not shown on the previous drawings. These pockets are designed to collect any surplus ink, and hold it in readiness to meet the requirements of the nib. This form of feed allows practically the whole of the barrel to be at disposal as an ink reservoir, as there are no internal projections. It is stated by the manufacturers that their pens will hold sufficient ink to write from 16,000 to 30,000 words. I have given two of these pens a severe trial, and the only fault I have to find with them is that they will not write without ink. Mr. Symonds, of Messrs. Mordan & Co., as well as Mr. Sloan, of Messrs. Hardmuth & Co., have been good enough to give me many facilities for testing these pens.

In Fig. 197 is a drawing of the "Hearson" pen, consisting of three parts, viz., the reservoir, the point section, and the nib of barrel type. It will be remembered that this has already been described in detail, as having a steel barrel nib enveloped in an India-rubber casing.

Fig. 198 shows the feed bar of the "Neptune" fountain pen. It will be seen to consist of a tube having a longitudinal slice cut from the rear end, while the other or front end is formed into two blades or fingers, one of which lies above the nib, and the other below it, in close contact. Sometimes there is only one finger, or, in other words, a single feed. I need hardly call attention to the fact that there are three different kinds of feed used in fountain pens, viz.: Single feed, top; single feed, bottom; double feed, top and bottom; one or other of which is adopted.

Fig. 199 is the "Wirt" pen (P. E. Wirt, 1885, 1496). This is a pen of the single feed type. The feed bar, too, is on the top of the nib. The feed bar consists of a single blade of vulcanite, about 2½ inches long, reaching nearly to the point of the nib, and extending backward into the ink reservoir, the rear part being formed somewhat like a paddle or oar. Air finds its way under the nib, and bubbles upward through the body of ink, while the ink by capillary force is fed along the bar. In general appearance the Wirt pen is very like other fountain pens. I had the good fortune to become possessed of one of these pens, which I used regularly for nine or ten years, and it is still as good as new. The drawing now shown is taken from the pen referred to, and the manufacturers have recently afforded me an opportunity to test a more modern pen, which I find equally efficient.

Moore's "Non-leakable" pen (Fig. 200) is another of those pens designed to prevent leakage when carried in the pocket, and it fully justifies what is thus claimed for it. The pen, or nib, can be drawn within the barrel by means of the slide or thimble, S, attached to the rear end of the elongated feed, F, which passes through the end of the barrel, and is screwed into the plug, P. A stop pin, A, prevents too much movement. The cap is provided with a screw thread, by which it can be securely screwed on the open end of the barrel, thus insuring a sealed joint. A projecting rod, C, in the cap prevents any injury to the point of the nib when the cap is screwed down, as it abuts against the plug, P, and prevents any movement of the pen. I have given four of these pens a severe trial, and cannot speak too highly of them. They appear to be absolutely non-leakable when closed, no matter in what position they may be carried, and under all conditions they are perfect of their kind.

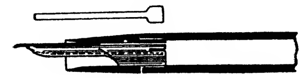
The "Horton" pen, shown in section in Fig. 201, is very similar to the following pen. It will be noted, however, that the sleeve nut has a double groove or thread, and also that there is a movable point section, but the movements are otherwise identical.

The distinctive feature of "Caw's Safety" fountain pen (Fig. 202) is the method whereby the pen-point is made to recede into the ink holder. The illustration shows clearly how this is effected. It will be seen that the feed bar, F, into which is fixed the nib, is elongated, and its rear end enters a cylinder having a spiral groove cut in it. A pin attached to the feed bar passes through the spiral groove, and is free to slide up or down in a straight groove cut in the barrel of the pen. The cylinder, C, is attached to the milled portion, M, of the pen, and on turning M, the cylinder, C, revolves with it, causing the feed bar, F, to travel, and the nib is thus propelled or withdrawn into the reservoir of ink; if the latter is desired, then the cap is screwed on at K, preventing the outflow of ink in whatever position the pen may be carried. It will be evident that when the nib is propelled, the feed bar, enlarged at that point, closes up the restricted aperture of the barrel, so that no ink can escape other than is required to supply the nib. I have tested one of these pens, which Messrs. Eyre & Spottiswoode kindly sent for my inspection a few days ago, and I find that it leaves nothing to be desired.

The "Swift" pen (Fig. 203) belongs to that class which makes special provision against risk of leakage, when out of use or when lying in a horizontal position. This end is accomplished by means of the valve, V, operated from the upper end, E, of the pen, which when screwed down, closes the ink-passage. The feed is of a very simple description, as may be seen. The ink passes along the tapering channel to the under side of the pen, I, air being admitted at the opening, A. The nib is fixed in the slit, N, provided for it. It appears to be identical with W. T. Shaw's patent of 1897, already described and illustrated.

An early form of pen (Fig. 204) of the self-filling type is the "Automatic." The specimen I am about

Fig. 192.

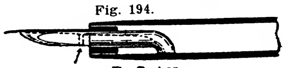


The Stafford

Fig. 193.

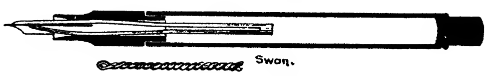
The Swallow.

Fig. 194.



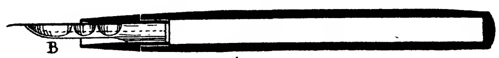
The Parker

Fig. 195.



Swan.

Fig. 196.



The Waterman

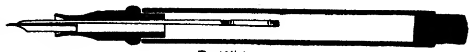
Fig. 197.

Hearson

Fig. 198.

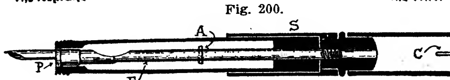
The Neptune.

Fig. 199.



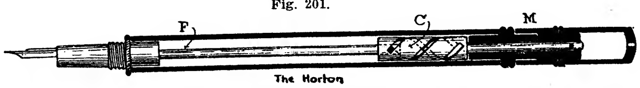
The Wirt.

Fig. 200.



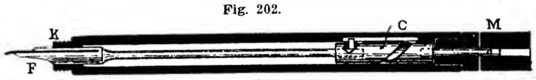
Moore's Non-leakable

Fig. 201.



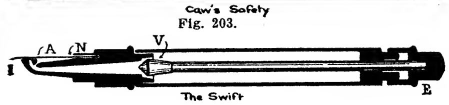
The Horton

Fig. 202.



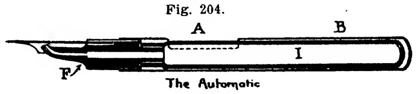
Caw's Safety

Fig. 203.



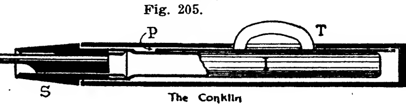
The Swift

Fig. 204.



The Automatic

Fig. 205.



The Conklin

[illegible] been in my possession since about 1878. [illegible]ructed entirely of metal with the exception [illegible] ink container, *I*, which is a flexible rubber tube closed at one end, and attached to the feed point, *F*, at the other end. In the casing, *B*, is an opening, *A*, placed in such a position that the thumb may readily be placed upon it so as to create a pressure on the ink container, *I*, and thus force a supply of ink to the nib as required. To fill the pen, the casing, *B*, is removed, the container is compressed to expel all the air, and placing the point in an ink bottle, the container is allowed to expand when it becomes charged with ink. A cap is provided for the protection of the nib. This pen differs in one respect from that of Michell, in that the ink is delivered underneath the nib, whereas it will be remembered, perhaps, that in Michell's patent, the ink was delivered on the back of the nib.

The "Conklin" pen, shown in Fig. 205, is an improved form of the "Automatic" just described. Its method of refilling is precisely the same, but a pressure bar, *P*, is provided, which extends practically the entire length of the flexible ink container, *I*. When the thumb-piece, *T*, is pressed down the container, *I*, is flattened, and thus it is emptied of air. The casing of the pen is of vulcanite, and the point section, *S*, is fitted into it without any screw thread, as an ink-tight joint is unnecessary. The ink-container may be readily and cheaply renewed when necessary, and for those who like a self-filling pen this one ought to find favor. The method of filling will be shown presently.

(To be continued.)

CEMENT MATERIALS AND INDUSTRY OF THE UNITED STATES.*

By EDWIN C. ECKEL.

DEFINITION OF PORTLAND, NATURAL, AND PUZZOLAN CEMENTS.

BEFORE taking up the subject of the materials and manufacture of cements, it is advisable to define the four great classes which are included in the group of "hydraulic cements," as that term is used by the engineer. The relationship of the various cementing materials† can be concisely expressed as in the following diagram:

Nonhydraulic cements	Plaster of Paris, cement plaster, Keene's cement, etc. Common lime.
Hydraulic cements	Hydraulic lime. Natural cements. Portland cements. Puzzolan cements.

Nonhydraulic Cements.—Nonhydraulic cements do not have the property of "setting" or hardening under water. They are made by burning, at a comparatively low temperature, either gypsum or pure limestone. The products obtained by burning gypsum are marketed as "plaster of Paris," "cement plaster," "Keene's cement," etc., according to details in the process of manufacture. The product of burning limestone is common lime.

Hydraulic Cements.—The hydraulic cements are those which set when used under water, though the different kinds differ greatly in the extent to which they possess this property, which is due to the formation during manufacture of compounds of lime with silica, alumina, and iron oxide.

On heating a pure limestone ($CaCO_3$) containing less than, say, 10 per cent of silica, alumina, and iron oxide together, its carbon dioxide (CO_2) is driven off, leaving more or less pure calcium oxide (CaO—quicklime or common lime). If the limestone contains much silica, alumina, or iron oxide, the result is quite different.

Natural Cements.—Natural cements are produced by burning a naturally impure limestone, containing from 15 to 40 per cent of silica, alumina, and iron oxide, at a comparatively low temperature, about that of ordinary lime burning. The operation can therefore be carried on in a kiln closely resembling an ordinary lime kiln. During the burning the carbon dioxide of the limestone is almost entirely driven off, and the lime combines with the silica, alumina, and iron oxide, forming a mass containing silicates, aluminates, and ferrites of lime. If the original limestone contained much magnesium carbonate the burned rock will contain a corresponding amount of magnesia.

The burned mass will not slake if water be added. It is necessary, therefore, to grind it rather fine. After grinding, if the resulting powder (natural cement) be mixed with water it will harden rapidly. This hardening or setting will also take place under water. Natural cements differ from ordinary limes in two noticeable ways:

(1) The burned mass does not slake on the addition of water.

(2) The powder has hydraulic properties, i. e., if properly prepared, it will set under water.

Natural cements differ from Portland cements in the following important particulars:

(1) Natural cements are not made from carefully prepared and finely ground artificial mixtures, but from natural rock.

(2) Natural cements are burned at a lower temperature than Portland, the mass in the kiln never being heated high enough to even approach the fusing or clinkering point.

(3) Natural cements, after burning and grinding, are usually yellow to brown in color and light in weight, having a specific gravity of 2.7 to 3.1, while Portland cement is commonly blue to gray in color and heavier, its specific gravity ranging from 3 to 3.2.

(4) Natural cements set more rapidly than Portland cement, but do not attain so high tensile strength.

(5) Portland cement is a definite product, its percentages of lime, silica, alumina, and iron oxide varying only between narrow limits, while brands of natural cements vary greatly in composition.

Portland Cement.—Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, alumina, and iron oxide in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale, in which case the mixture should contain about three parts of the lime carbonate to one part of the clayey materials. The burning takes place at a high temperature, approaching 3,000 deg. F., and must therefore be carried on in kilns of special design and lining. During the burning, combination of the lime with silica, alumina, and iron oxide takes place. The product of the burning is a semi-fused mass called "clinker," which consists of silicates, aluminates, and ferrites of lime in certain fairly definite proportions. This clinker must be finely ground. After such grinding, the powder (Portland cement) will set under water.

Puzzolan Cements.—The cementing materials included under this name are made by mixing powdered slaked lime with either a volcanic ash or a blast-furnace slag. The product is, therefore, simply a mechanical mixture of two ingredients, as the mixture is not burned at any stage of the process. After mixing, the mixture is finely ground. The resulting powder (puzzolan cement) will set under water.

Puzzolan cements are usually light bluish, and of lower specific gravity and less tensile strength than Portland cement. They are better adapted to use under water than in air, as is explained later.

MATERIALS AND MANUFACTURE OF PORTLAND CEMENT.

Definition of Portland Cement.

Portland cement is an artificial product, obtained by finely pulverizing the clinker produced by burning to semi-fusion an intimate mixture of finely ground calcareous and argillaceous material, this mixture consisting, approximately, of one part of silica and alumina to three parts of carbonate of lime (or an equivalent amount of lime).

Composition and Constitution.

The ideal Portland cement, toward which cements as actually made tend in composition, would consist exclusively of tricalcic silicate, and would be therefore composed entirely of lime and silica in the following proportions: Lime (CaO), 73.6 per cent; silica (SiO_2), 26.4 per cent.

Such an ideal cement, however, can not be manufactured under present commercial conditions, for the heat required to clinker such a mixture can not be attained in any working kiln.

In order to prepare Portland cement in actual practice, therefore, it is necessary that some other ingredient or ingredients be present to serve as a flux in aiding the combination of the lime and silica, and such aid is afforded by the presence of alumina and iron oxide.

Alumina (Al_2O_3) and iron oxide (Fe_2O_3), when present in noticeable percentages, serve to reduce the temperature at which combination of the lime and silica (to form $3CaO.SiO_2$) takes place; and this clinkering temperature becomes further and further lowered as the percentages of alumina and iron are increased. The strength and value of the product, however, also decrease as the alumina and iron increase; so that in actual practice it is necessary to strike a balance between the advantage of low clinkering temperature and the disadvantage of weak cement, and thus to determine how much alumina and iron should be used in the mixture.

It is generally considered that whatever alumina is present in the cement is combined with part of the lime to form the compound $2CaO.SiO_2$—dicalcic aluminate. It is also held by some, but this fact is somewhat less firmly established than the last, that the iron present is combined with the lime to form the compound $2CaO.Fe_2O_3$. For the purposes of the present paper it will be sufficient to say that, in the relatively small percentages in which iron occurs in Portland cement, it may for convenience be considered as equivalent to alumina in its action, and the two may be calculated together.

Raw Materials for Portland Cement.

For the purposes of the present section it will be sufficiently accurate to consider that a Portland-cement mixture, when ready for burning, will contain about 75 per cent of lime carbonate ($CaCO_3$) and 20 per cent of silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3) together, the remaining 5 per cent including any magnesium carbonate, sulphur, and alkalies that may be present.

The essential elements which enter into this mixture—lime, silica, alumina, and iron—are all abundantly and widely distributed in nature, occurring in different forms in many kinds of rocks. It can therefore readily be seen that, theoretically, a satisfactory Portland-cement mixture could be prepared by combining, in an almost infinite number of ways and proportions, many kinds of raw material.

The almost infinite number of raw materials which are theoretically available are, however, reduced to a very few under existing commercial conditions.

The raw material which furnishes the lime is usually natural—a limestone, chalk, or marl—but occasionally it is an artificial product, such as the chemically precipitated lime carbonate which results as waste from alkali manufacture. The silica, alumina, and iron oxide of the mixture are usually derived from clays, shales, or slates; but in a few plants blast-furnace slag is used as the silica-aluminous ingredient in the manufacture of true Portland cement.

The various combinations of raw materials which are at present used in the United States in the manufacture of Portland cement may be grouped under six heads: (1) Argillaceous limestone (cement rock) and pure limestone; (2) pure hard limestone and clay or shale; (3) soft chalky limestone and clay; (4) marl and clay; (5) alkali waste and clay; (6) slag and limestone.

Value of Deposits of Cement Materials.

The determination of the possible value for Portland cement manufacture of a deposit of raw material is a complex problem, depending upon a number of distinct factors, the more important of which are as follows: (1) Chemical composition, (2) physical character, (3) amount available, (4) location with respect to transportation routes, (5) location with respect to fuel supplies, (6) location with respect to markets.

Ignorance of the respective importance of these factors frequently leads to an overestimate of the value of a deposit of raw material. Their effects may be briefly stated, as follows:

(1) Chemical Composition.—The raw material must be of correct chemical composition for use as a cement material. This implies that the material, if a limestone, must contain as small a percentage as possible of magnesium carbonate. Under present conditions 5 or 6 per cent is the maximum permissible. Free silica, in the form of chert, flint, or sand, must be absent, or present only in small quantity—say 1 per cent or less. If the limestone is a clayey limestone or "cement rock," the proportion between its silica and its alumina and iron should fall within the limits

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3} > 2 : \frac{SiO_2}{Al_2O_3 + Fe_2O_3} < 3.5.$$

A clay or shale should satisfy the above equation, and should be free from sand, gravel, etc. Alkalies and sulphates should, if present, not exceed 3 per cent.

(2) Physical Character.—Economy in excavation and crushing requires that the raw materials should be as soft and as dry as possible.

(3) Amount Available.—A Portland cement plant running on dry raw materials, such as a mixture of limestone and shale, will use approximately 20,000 tons of raw material a year per kiln. Of this about 15,000 tons are limestone and 5,000 tons shale. Assuming that the limestone weighs 160 pounds per cubic foot, which is a fair average weight, each kiln in the plant will require about 190,000 cubic feet of limestone a year. As the shale or clay may be assumed to contain considerable water, a cubic foot will probably contain not over 125 pounds of dry material so that each kiln will also require about 80,000 cubic feet of shale or clay.

A cement plant is an expensive undertaking, and it would be folly to locate a plant with less than a twenty years' supply of raw material in sight. In order to justify the erection of a cement plant, there must be in sight at least 3,800,000 cubic feet of limestone and 1,600,000 cubic feet of clay or shale for each kiln.

(4) Location with Respect to Transportation Routes.—Portland cement is for its value a bulky product and is therefore much influenced by transportation routes. To locate a plant on only one railroad, unless the railroad officials are financially connected with the cement plant, is simply to invite disaster. At least two transportation routes should be available, and it is best of all if one of these be a good water route.

(5) Location with Respect to Fuel Supplies.—Every barrel (380 pounds) of Portland cement marketed implies that at least 200 to 300 pounds of coal have been used in the power plant and the kilns. In other words, each kiln in the plant will, with its corresponding crushing machinery, use up from 6,000 to 9,000 tons of coal a year. The item of fuel cost is therefore highly important, for in the average plant about 30 to 40 per cent of the total cost of the cement will be chargeable to coal supplies.

(6) Location with Respect to Markets.—In order to achieve an established position in the trade a new cement plant should have (a) a local market area, within which it may sell practically on a non-competitive basis, and (b) easy access to a larger though competitive market area.

Methods of Manufacture of Portland Cement.

If the so-called "natural Portlands" are excluded, Portland cement may be regarded as an artificial product obtained by burning to semi-fusion an intimate mixture of pulverized materials containing lime, silica, and alumina in varying proportions within certain narrow limits, and by crushing finely the clinker resulting from this burning. If this restricted definition of Portland cement be accepted, four points may be regarded as being of cardinal importance: (1) The cement mixture must be of the proper chemical composition; (2) the materials must be carefully ground and intimately mixed before burning; (3) the mixture must be burned at the proper temperature; (4) after burning, the resulting clinker must be finely ground.

As the chemical composition of the mixture can be more advantageously discussed after the other three subjects have been disposed of, it will therefore be taken up last.

Preparation of the Mixture for the Kiln.

In the preparation of the mixture for the kiln the raw materials must be reduced to a very fine powder and intimately mixed. The raw materials are usually

* Abstract from Bulletin 243 of United States Geological Survey.

† For a more detailed discussion see Municipal Engineering, vol. xxiv., 1903, pp. 335-336, and American Geologist, vol. xxix., 1902, pp. 146-154.